

# The Efficacy of Air Pollution Control Efforts: Evidence from AURA



Presented at the Aura Science Team Meeting  
by

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UMD/URF Cessna  
Photo by J. Stehr



Canty et al. showed that OMI NO<sub>2</sub> data help evaluate and improve CMAQ.

## Posters on Air Quality in the Eastern US

- Carpenter et al., OMI H<sub>2</sub>CO and isoprene emissions.
- Hembeck et al., CMAQ/CB05 BEIS vs MEGAN and ROx.
- Montgomery et al. Ship emissions

# Overview

- The main air quality issues in the US are  $O_3$ , fine particulate matter (PM<sub>2.5</sub>), and haze.
- The main precursors are  $NO_x$ ,  $SO_2$ , and VOC's.  $NO_2$  has plummeted (press release) and  $O_3$  with it. (CSAPR)
- The regulatory models (CMAQ and CAMx) show  $O_3$  as a *local* problem; observations show it as a *regional* problem.
- Emissions for  $SO_2$  are monitored and well known; the lifetime (conversion to sulfate) is not.
- Using OMI obs in combination with in situ measurements and models has led to advances in our ability to understand and improve air quality.

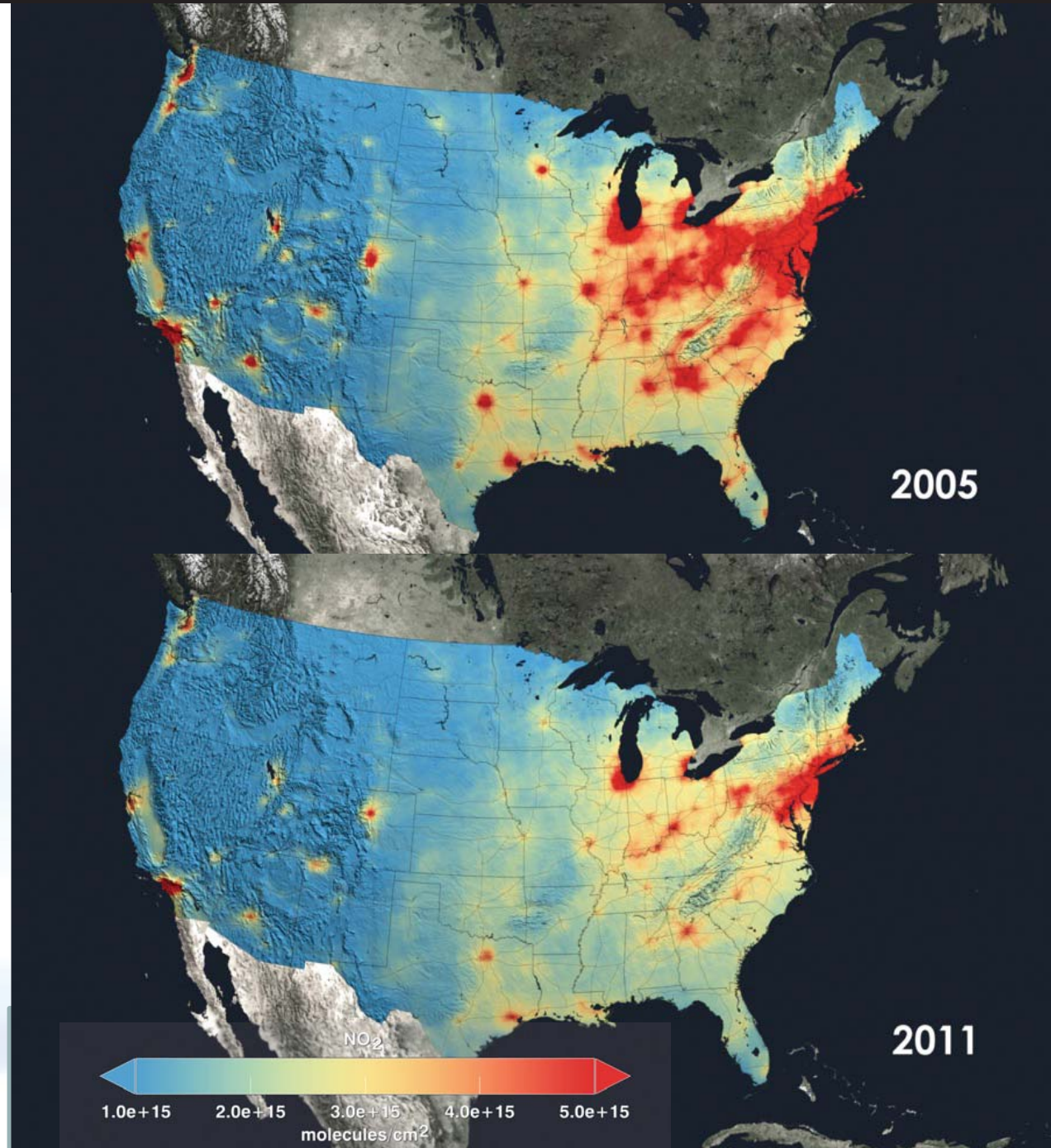




# NASA *Aura* OMI Shows Air Quality is Improving



- OMI nitrogen dioxide data indicate a 30-40% decrease in the pollutant's levels from 2005 to 2011.
- NO<sub>2</sub> levels have dropped through the implementation of emission control devices on coal-burning power plants and more fuel-efficient cars.
- NASA AQAST members are working with state air quality agencies to demonstrate the effectiveness of their efforts to improve air quality and to find novel uses of satellite data for air quality applications.



# Air Quality Media Campaign: *NASA ACAST Members Get the Word Out on Improving Air Quality*

- The vast majority of Americans believe their air quality is worsening and their tax dollars going to improving air quality are for naught.
- Air quality managers often complain of this erroneous perception by the general public.
- On June 27<sup>th</sup>, NASA ACAST members did over 20 live interviews (e.g., Fox News, The Weather Channel), several taped interviews (e.g., CNN), and numerous phone and email interviews.
- The story was reported in numerous news outlets (e.g., Smithsonian, Science World Report).

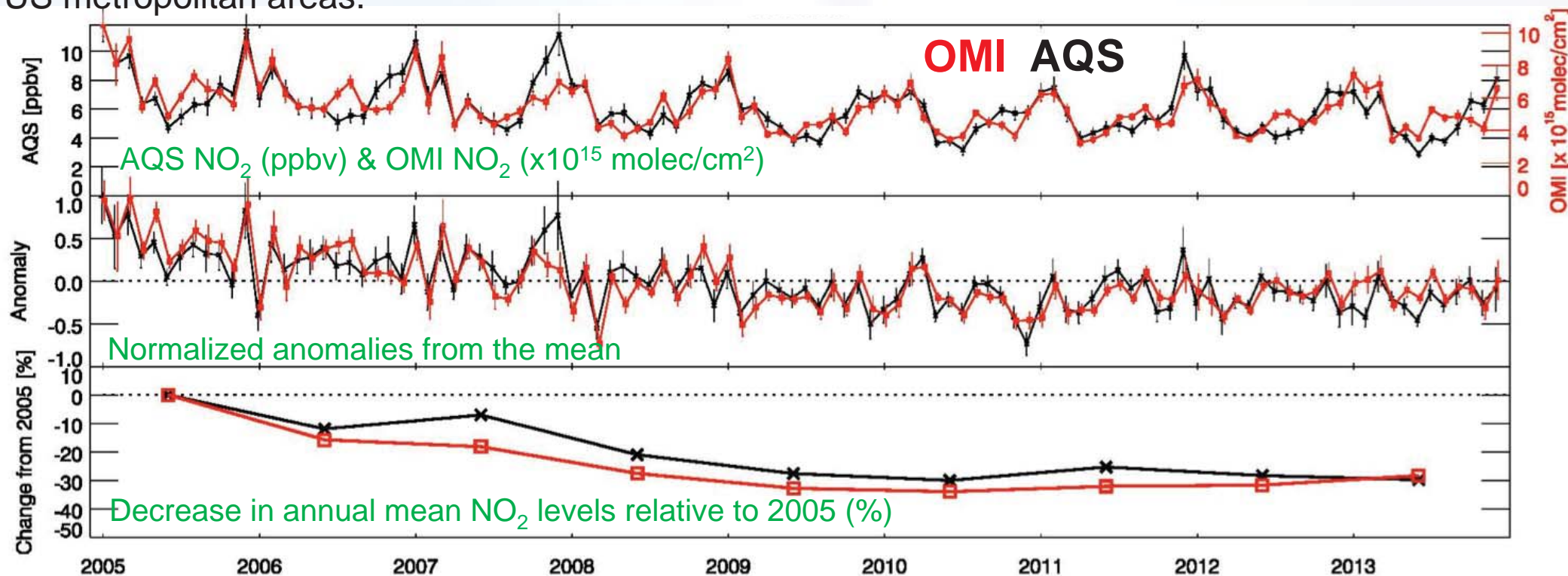




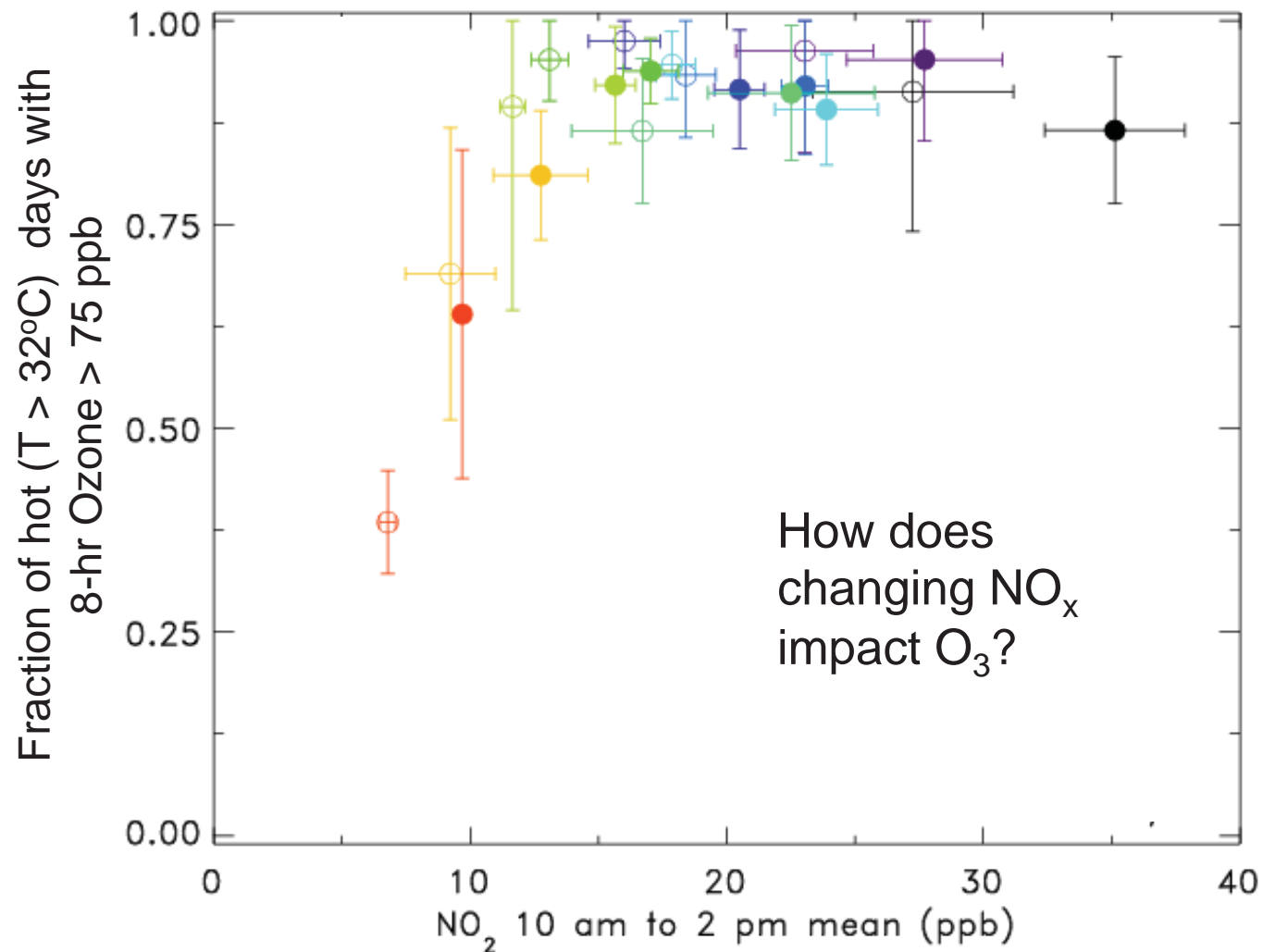


# OMI NO<sub>2</sub> trends compare well to “nose-level” trends

- Air quality managers want to understand the correspondence between satellite column data, such as OMI NO<sub>2</sub>, and ground-level values. (This is the focus of the NASA DISCOVER-AQ field campaign.) The graph below shows a comparison of monthly-averaged EPA Air Quality System (AQS) surface data and OMI data for sites in the Houston metropolitan area from 2005 to 2013.
- With a few exceptions, the normalized monthly anomalies (from the mean) of the satellite data mimic the anomalies in the surface data. Work is ongoing to identify the causes of any discrepancies.
- The annual trends (relative to 2005) agree well, indicating an approximately 30% decrease in NO<sub>2</sub> pollution in Houston. The agreement between OMI and AQS data is similarly good for most major US metropolitan areas.



As measured  $\text{NO}_x$  levels have gone down ...  
... So have ambient ozone levels



Observations show:  $\text{NO}_x$  reductions worked, but response is nonlinear; we had to get over the hump.

Aside:  $\text{H}_2\text{CO}$  shows no such correlation with this ozone trend.

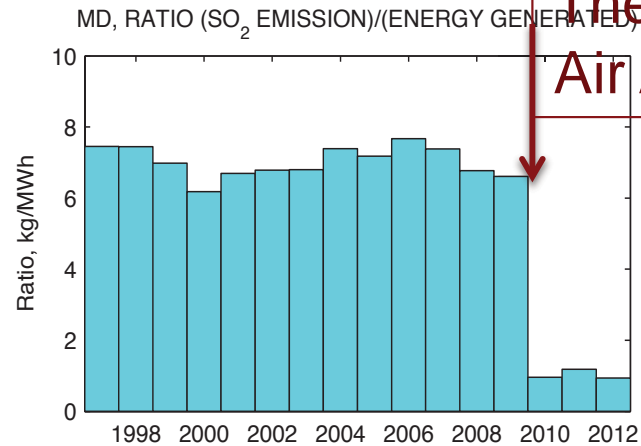
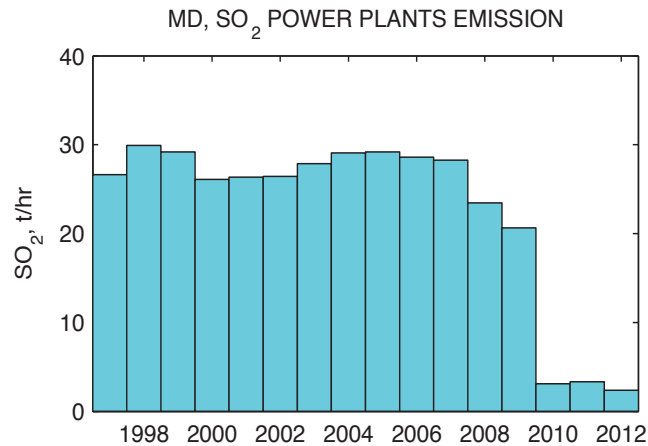
# An experiment of opportunity: SO<sub>2</sub>

In 2010, Maryland implemented the  
“Healthy Air Act”

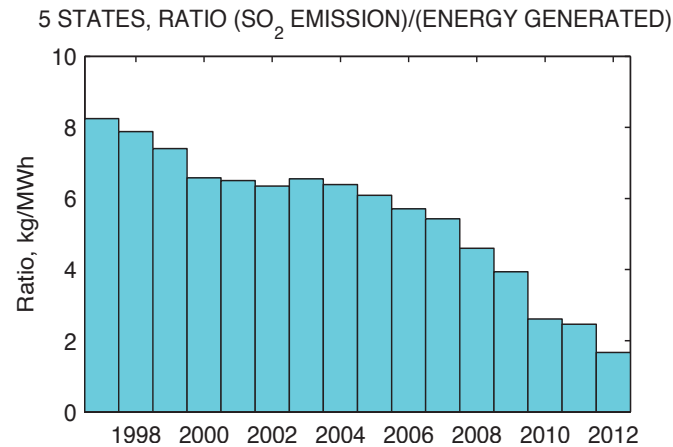
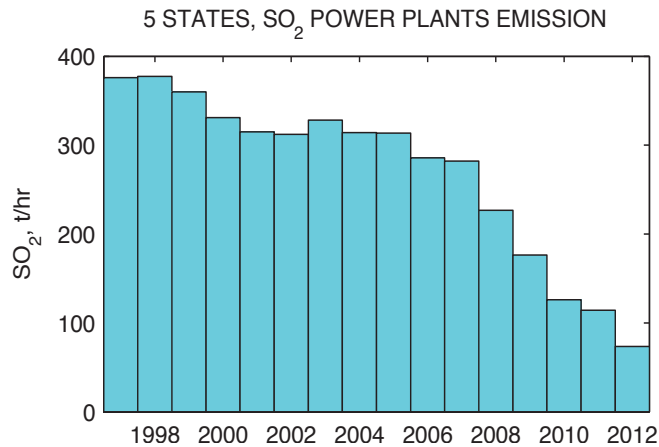




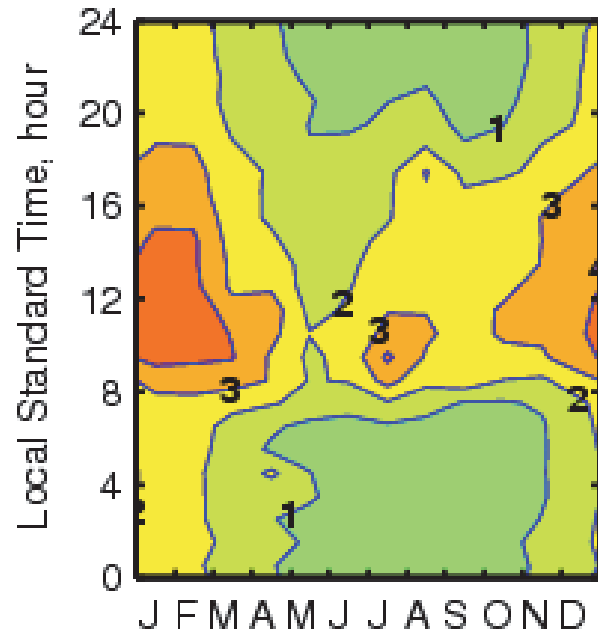
# Power Plant Emissions in Maryland and surrounding states.



The Healthy  
Air Act



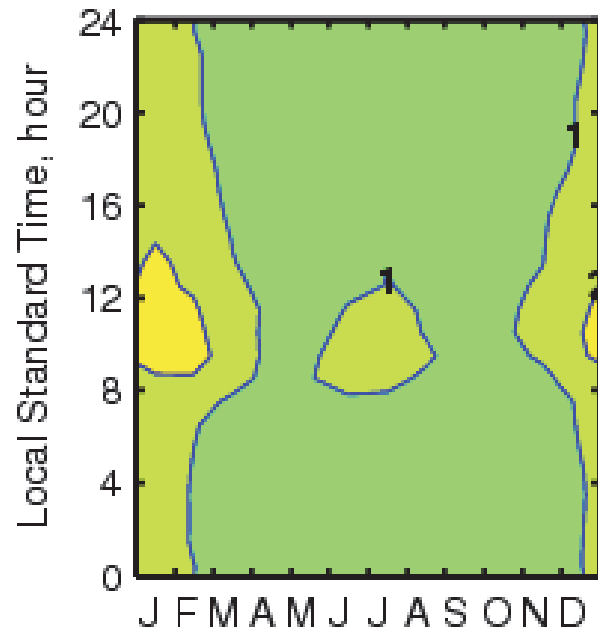
2006–2009 MEANS



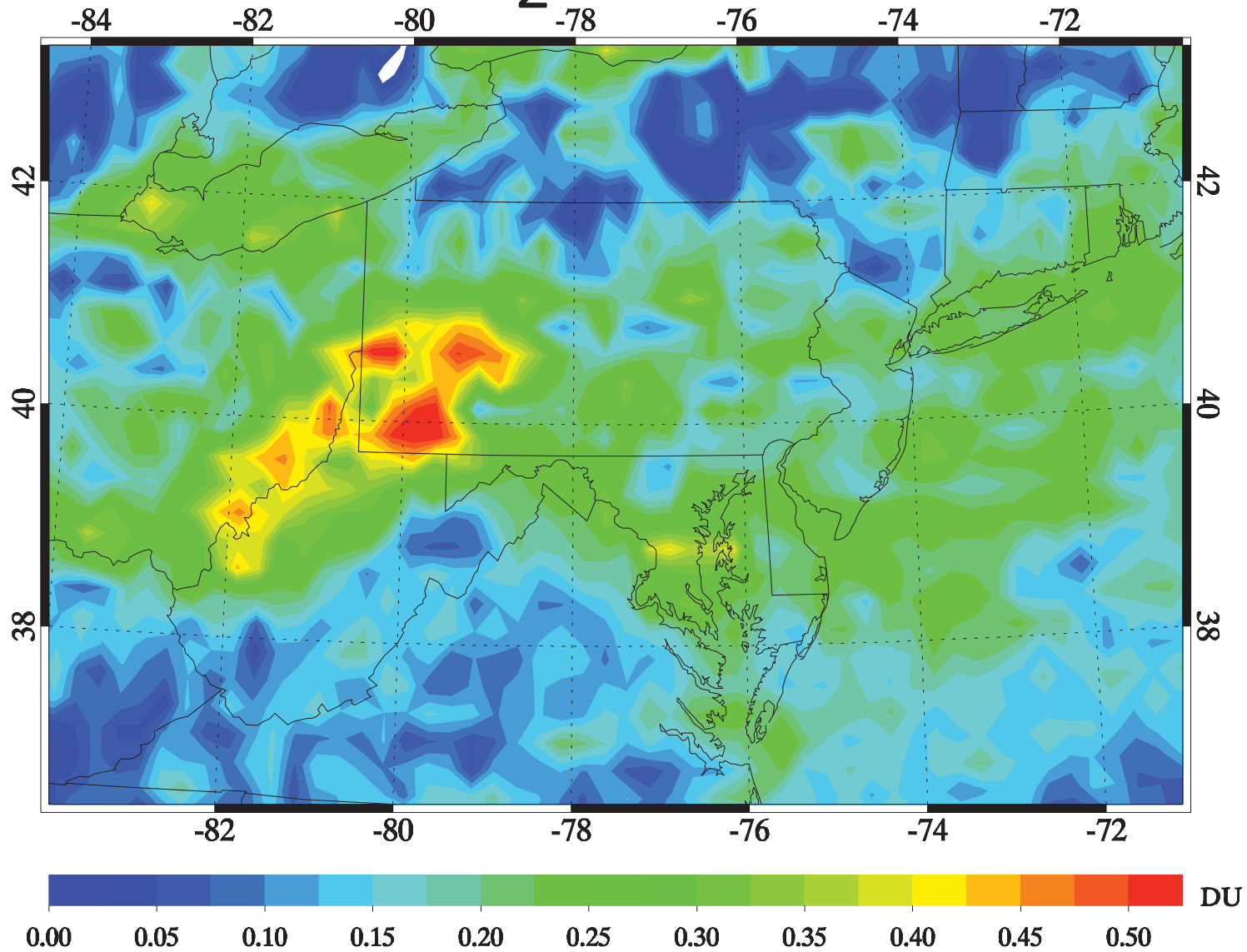
## Ambient $\text{SO}_2$ (ppb) at Beltsville, MD

- Daily cycle ~factor of two.
- Seasonal cycle ~factor of two.
- Dramatic decreases after Healthy Air Act.
- Maxima in mid day when PBL entrains plumes from aloft.
- Surface  $\text{SO}_2$  reflects emissions reductions.

2010–2013 MEANS

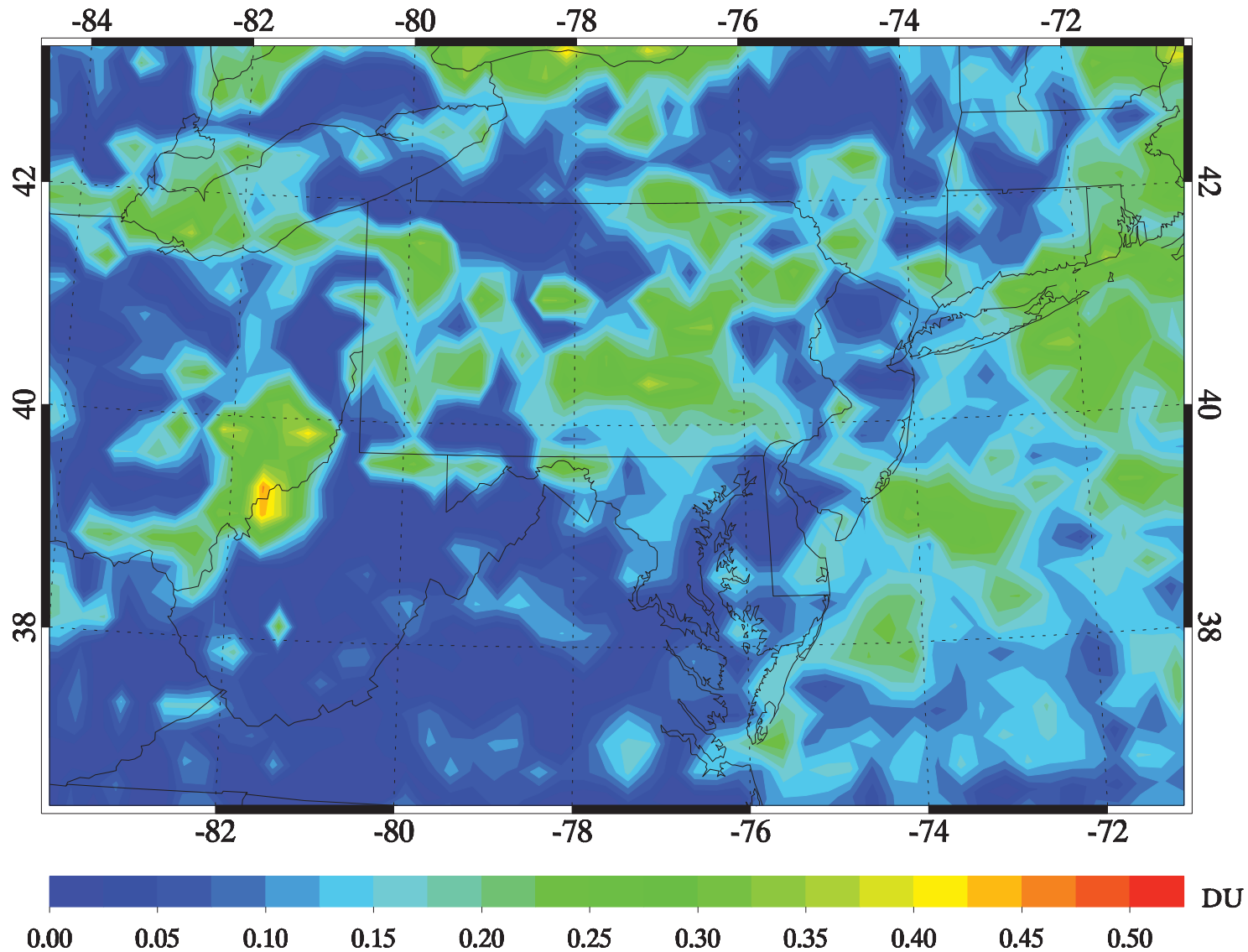


# OMI SO<sub>2</sub> 2005-2009

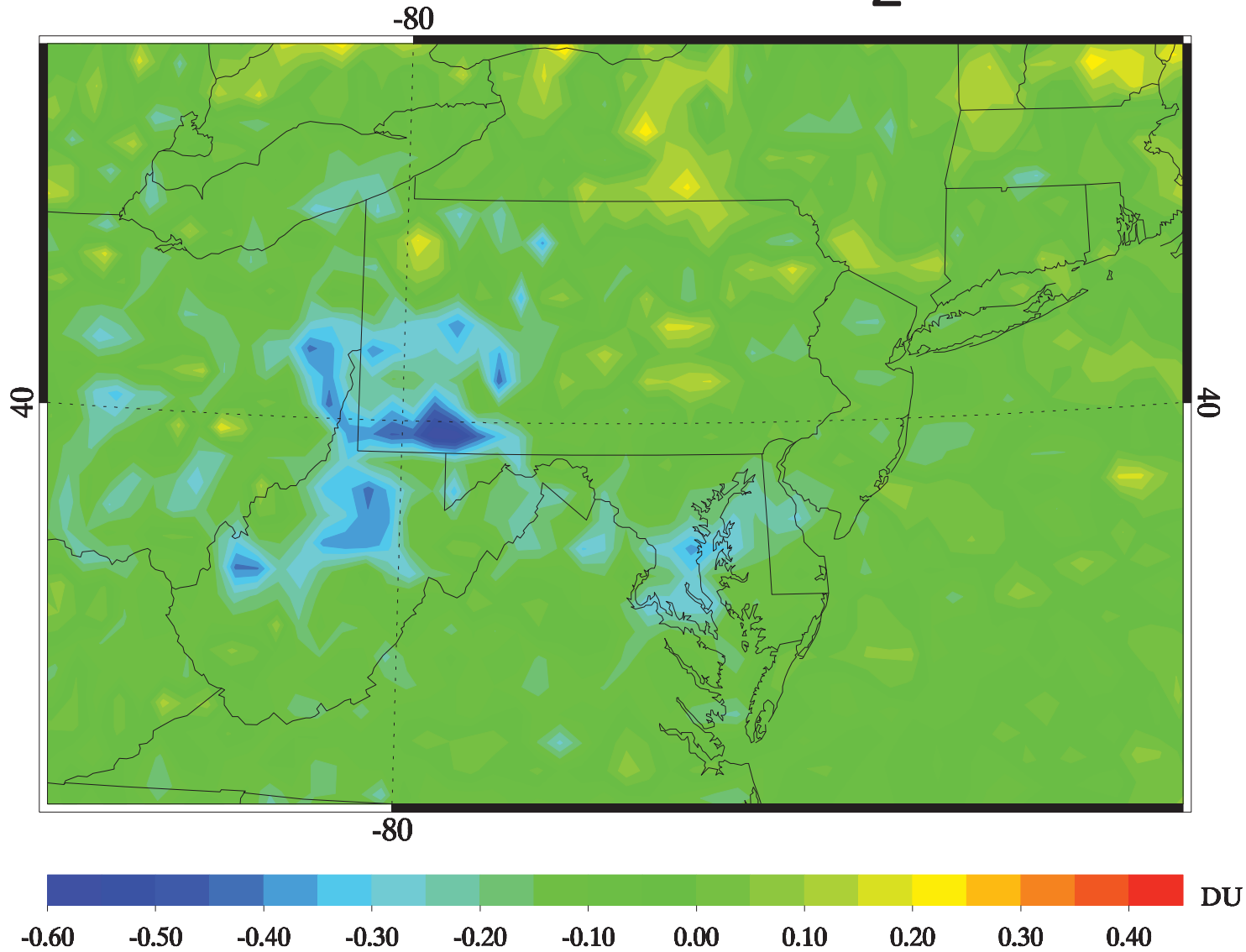




# OMI SO<sub>2</sub> 2010-2012



# Difference in SO<sub>2</sub> (DU)





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# Applying Satellite Data to Air Quality Management

Research conducted by the NASA Air Quality  
Applied Sciences Team (AQA) shows that  
Earth science data are a great potential  
resource for air quality managers

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September issue of  
EM dedicated to  
DISCOVER-AQ.  
Six articles



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## DISCOVER-AQ

Advancing Strategies for  
Air Quality Observations  
in the Next Decade



As part of this mission, scientists collect pollutant measurements using aircraft, sondes, satellites, and ground-based instruments.

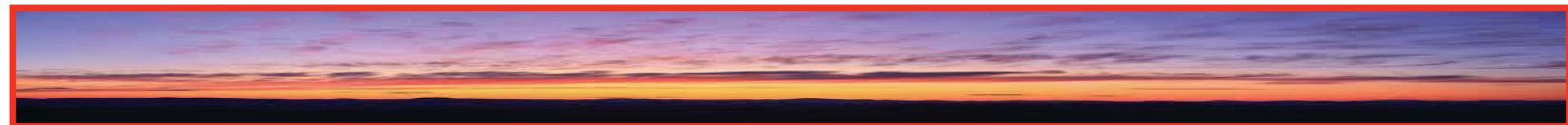
# Interim conclusions

In situ and remote obs in agreement

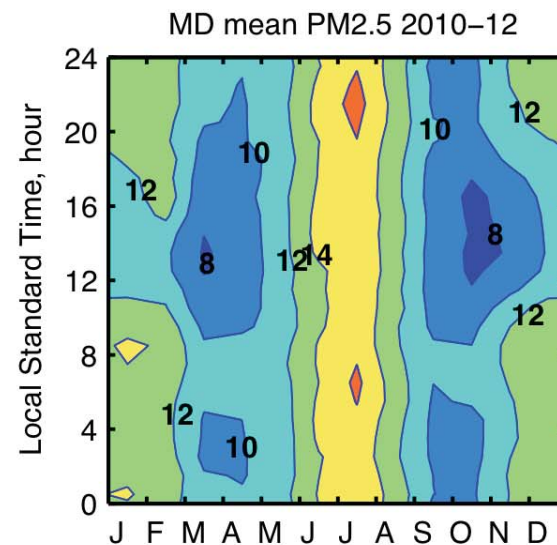
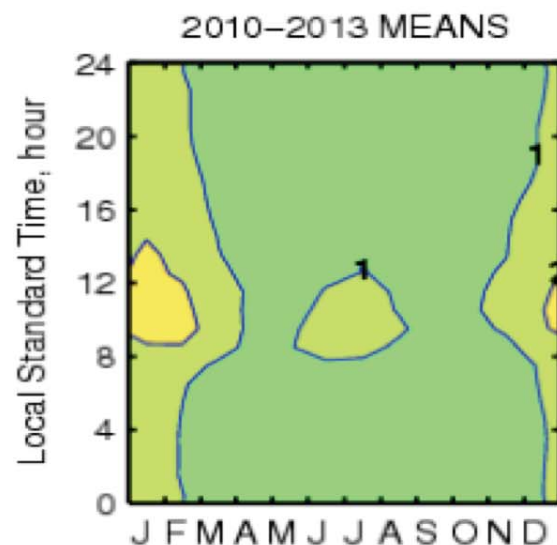
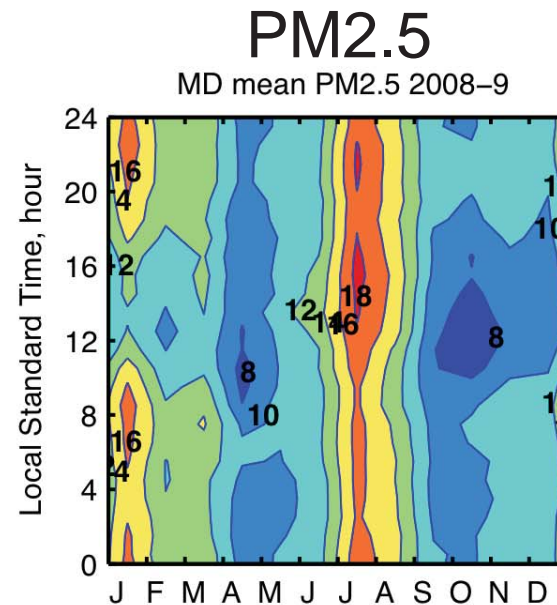
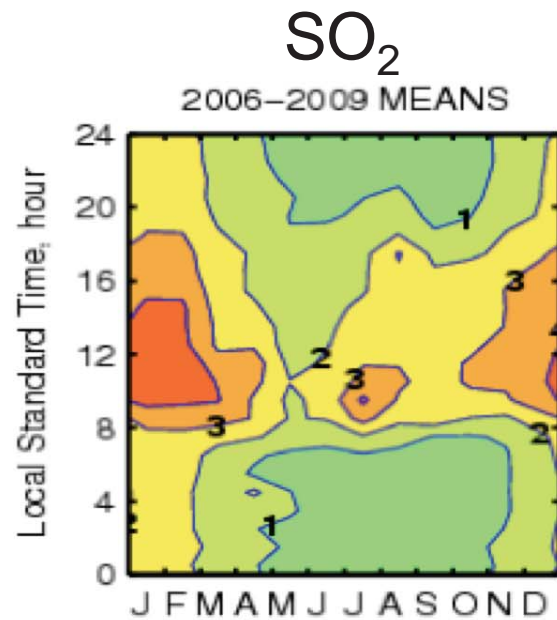
The good news: Local emissions reductions have an immediate and profound impact on local concentrations of  $\text{SO}_2$ .

The lifetime of  $\text{SO}_2$  can be estimated from the column content and known emissions flux. Lee, Hains, et al., *JRG* 2011; Loughner et al, 2014.

CMAQ (EPA regulatory model) underestimates the lifetime of  $\text{NO}_x$ , but overestimates the emissions. Anderson et al., *Atmos. Environ.* 2014; Canty et al., 2014.



## The bad news: PM2.5 only fell modestly.

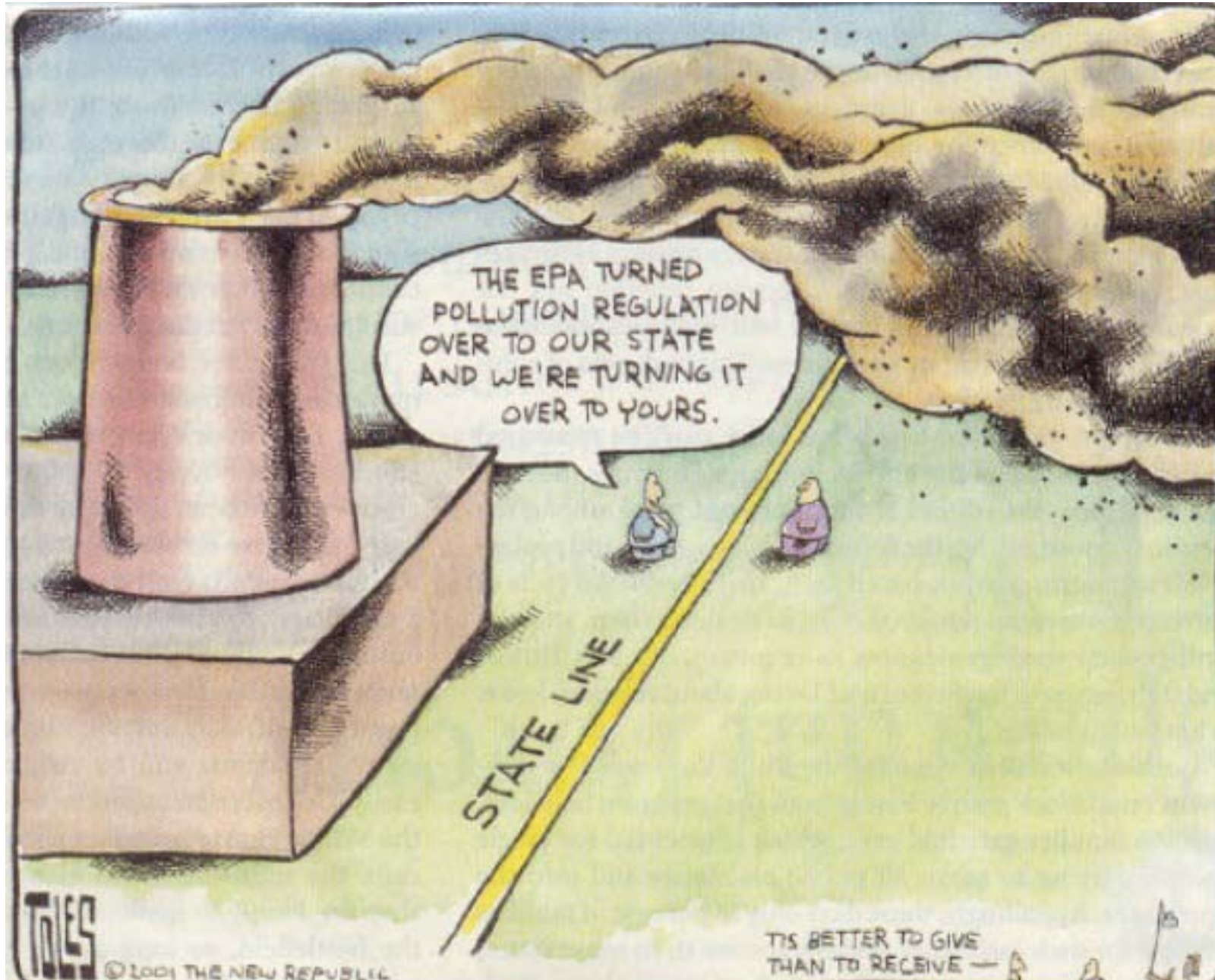


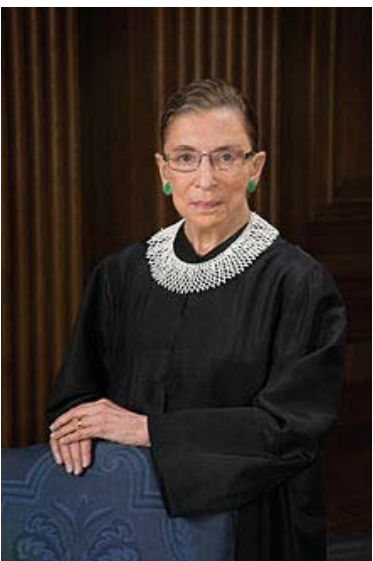
Why? Sulfate was dominant and has a longer lifetime than SO<sub>2</sub>.

SOA becoming dominant; it also has a lifetime of ~10 d.



# Life as a Downwind State





Justice Ginsburg, “The wind bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh, and whither it goeth.” The Holy Bible, John 3:8 (King James Version).

Justice Breyer, “the EPA faces this kind of regional problem, and it's a regional, not just a statewide problem....”

April 29, 2014 year, the **Supreme Court** upheld on the Cross-State Air Pollution Rule, CSAPR.

NASA data went into an *Amicus Brief*.

# Ongoing projects

- Helping CMAQ more accurately predict ozone.
- Maryland owes EPA a SIP. Local vs. regional measures?
- Impact of increasing oil natural gas and production (fracking).



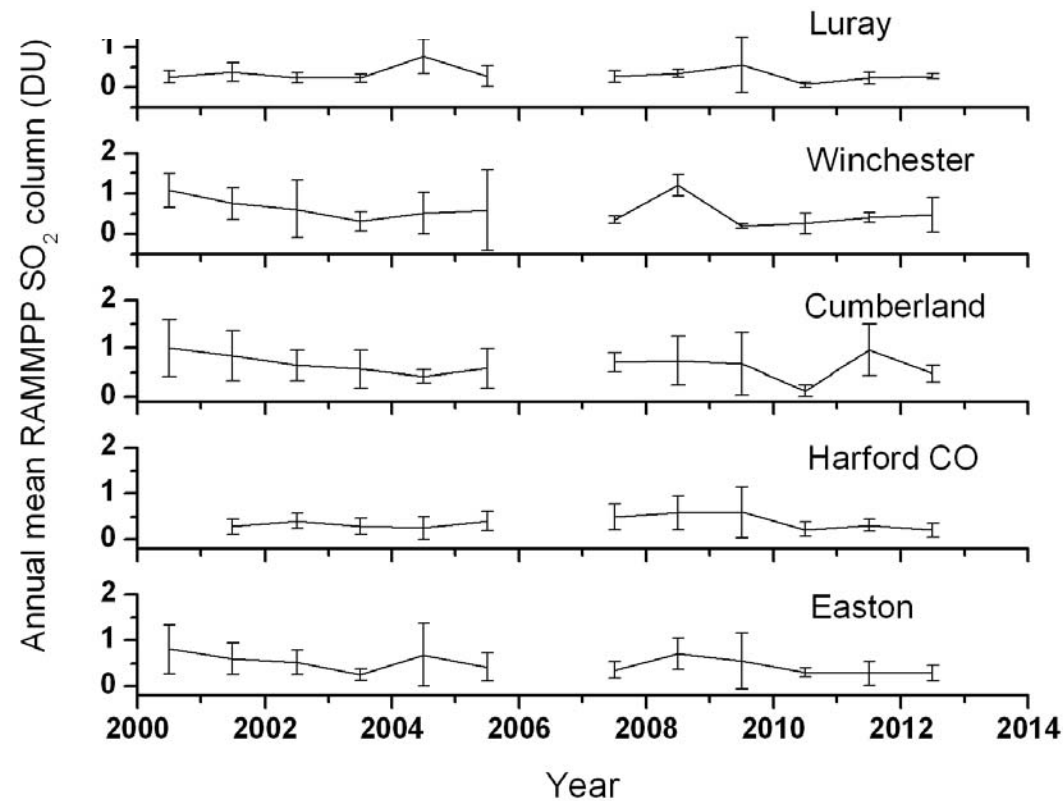
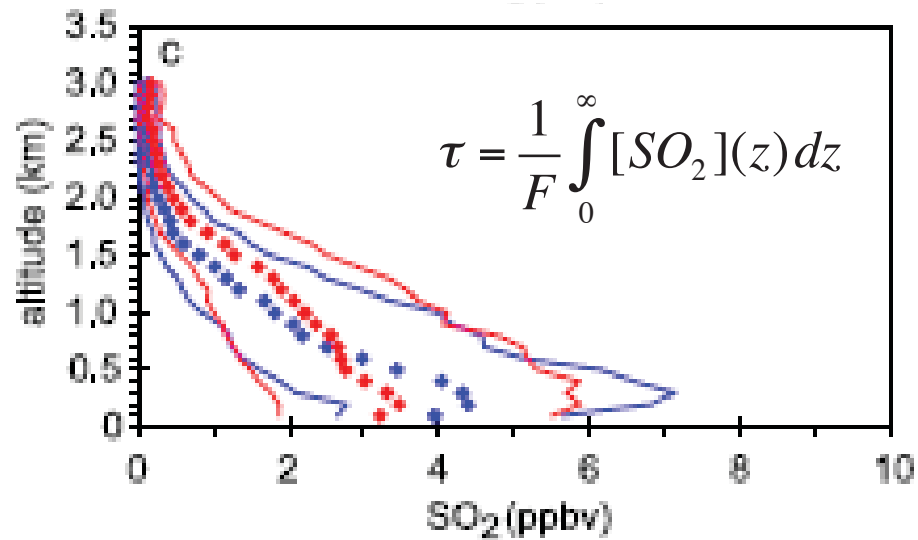


# Conclusions

- Air Quality managers are using satellite data including OMI!
- The Healthy Air Act produced 80% reductions in SO<sub>2</sub> emissions in Maryland starting in 2010.
- OMI and ambient measurements of short lived ( $24 \pm 10\text{hr}$ ) SO<sub>2</sub> showed dramatically and immediately AQ improvement.
- Longer lived ( $\sim 10\text{ d}$ ) PM<sub>2.5</sub> improved much less so.
- Both O<sub>3</sub> and H<sub>2</sub>CO correlate with T, but in long term trends only O<sub>3</sub> and NO<sub>2</sub> correlate.
- This tells policy makers to focus on NO<sub>x</sub> controls; both local and regional.

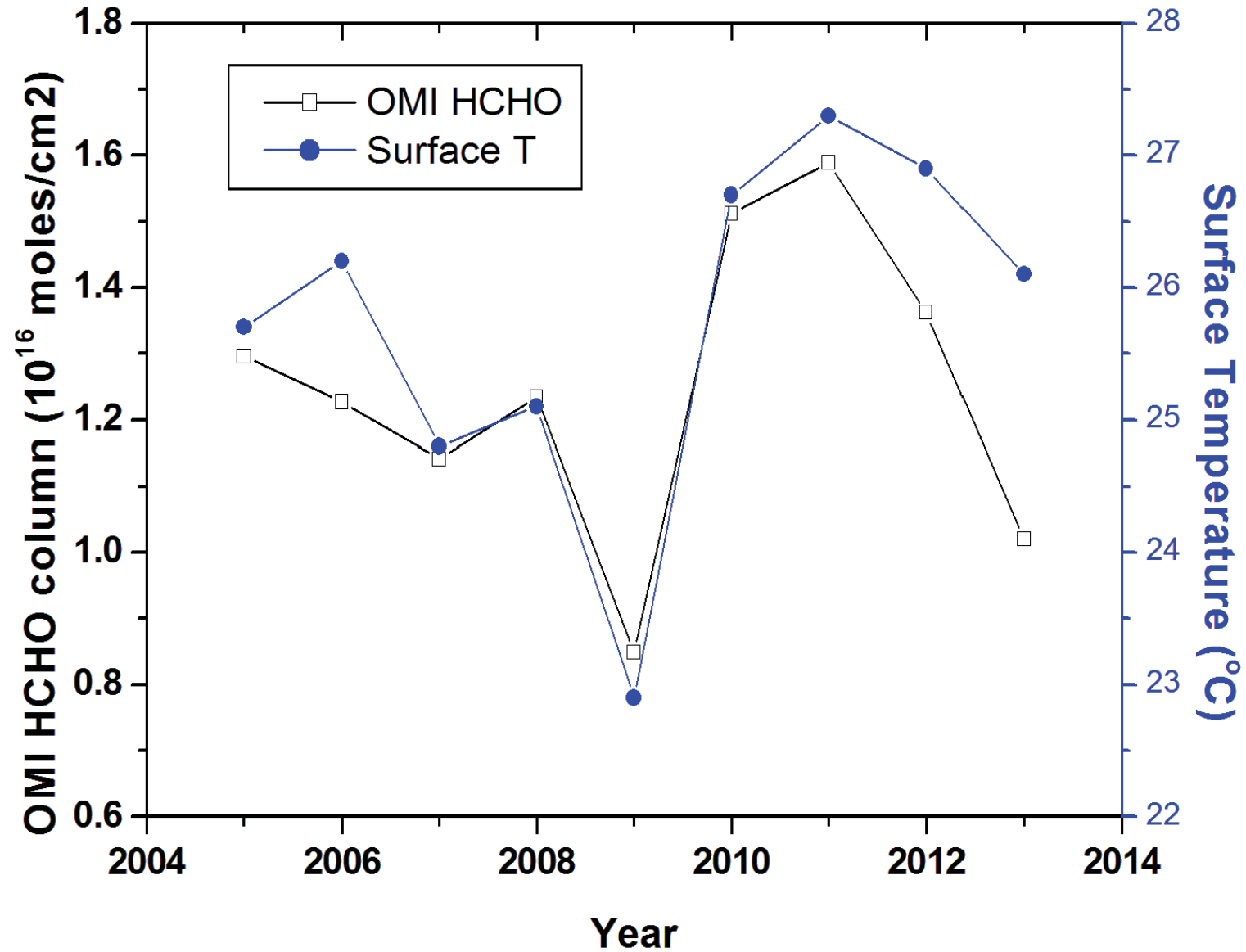


End

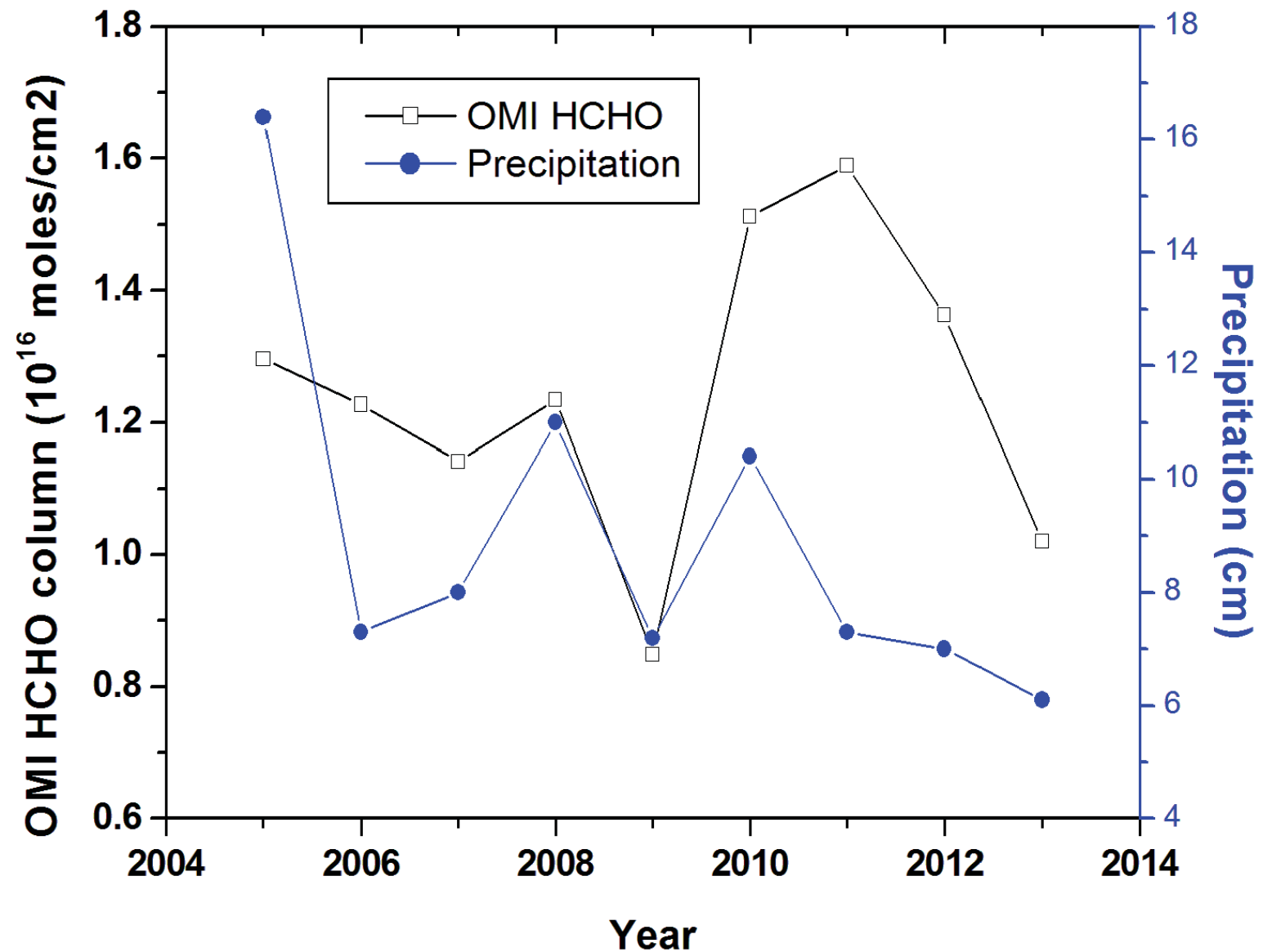


Aircraft profiles show great variability, but a significant SO<sub>2</sub> decrease.

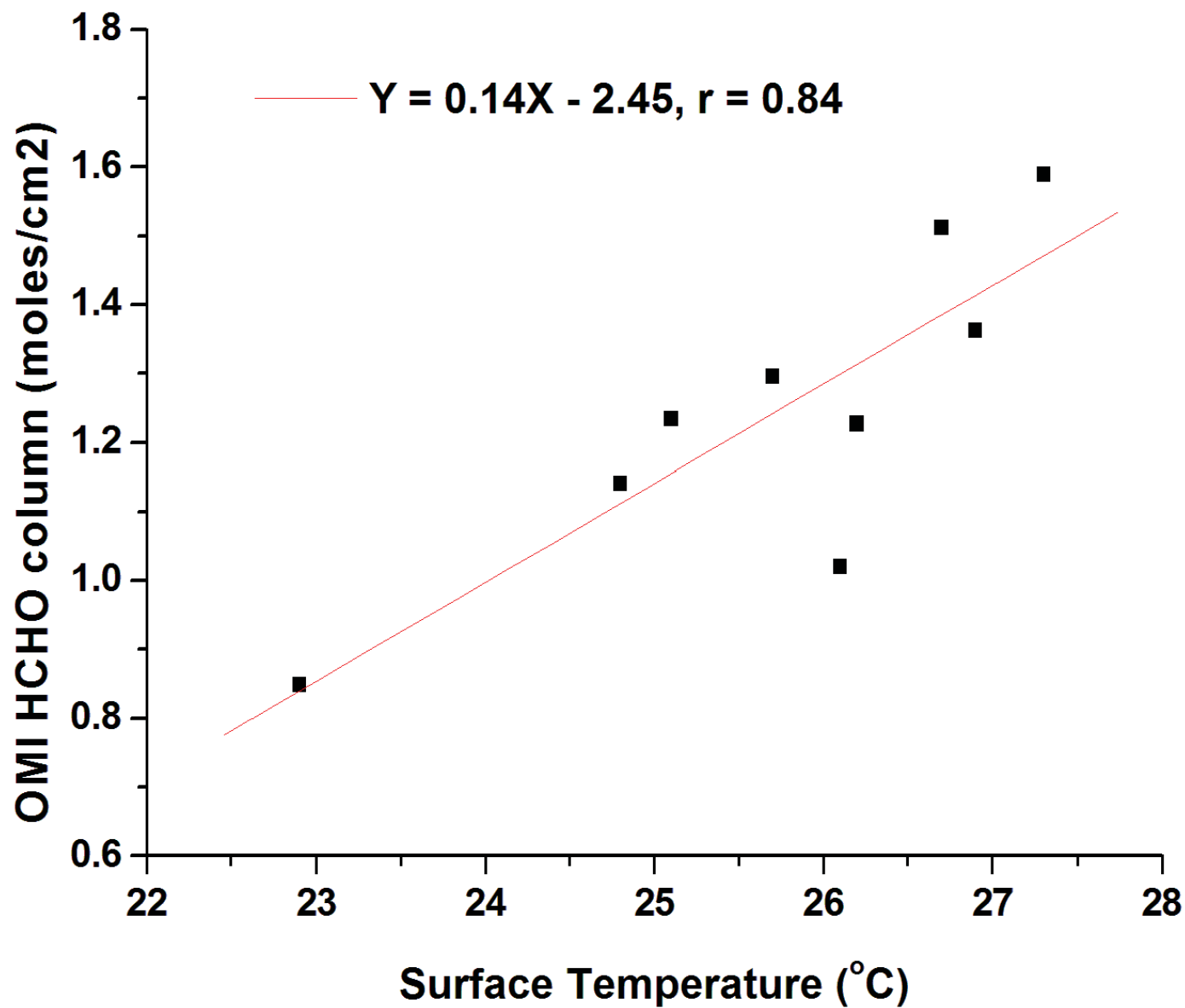




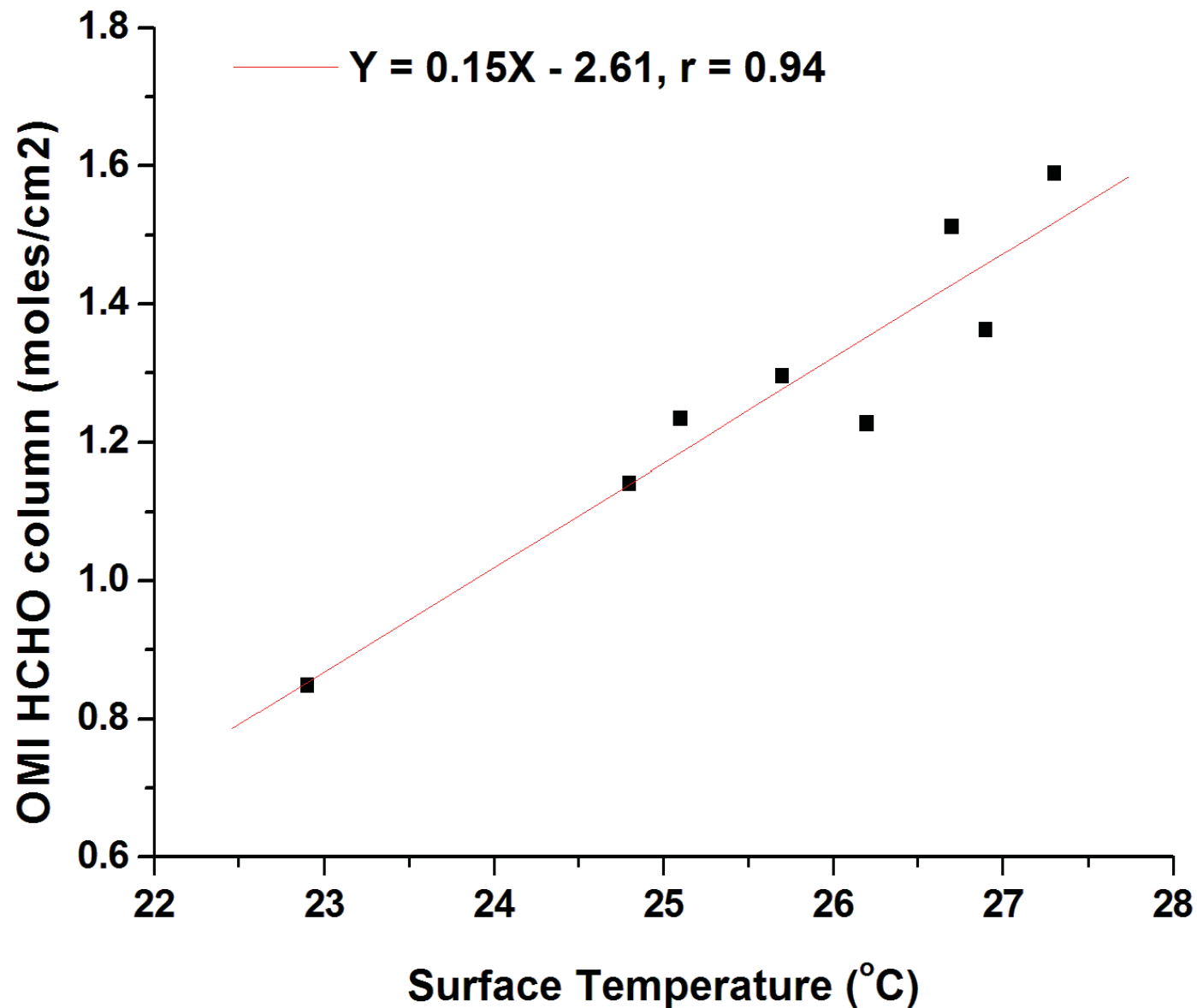
Time series of July OMI HCHO column vs. Surface Temperature



Time series of July OMI HCHO column vs. Precipitation  
→ No correlation and 2013 July is dry!

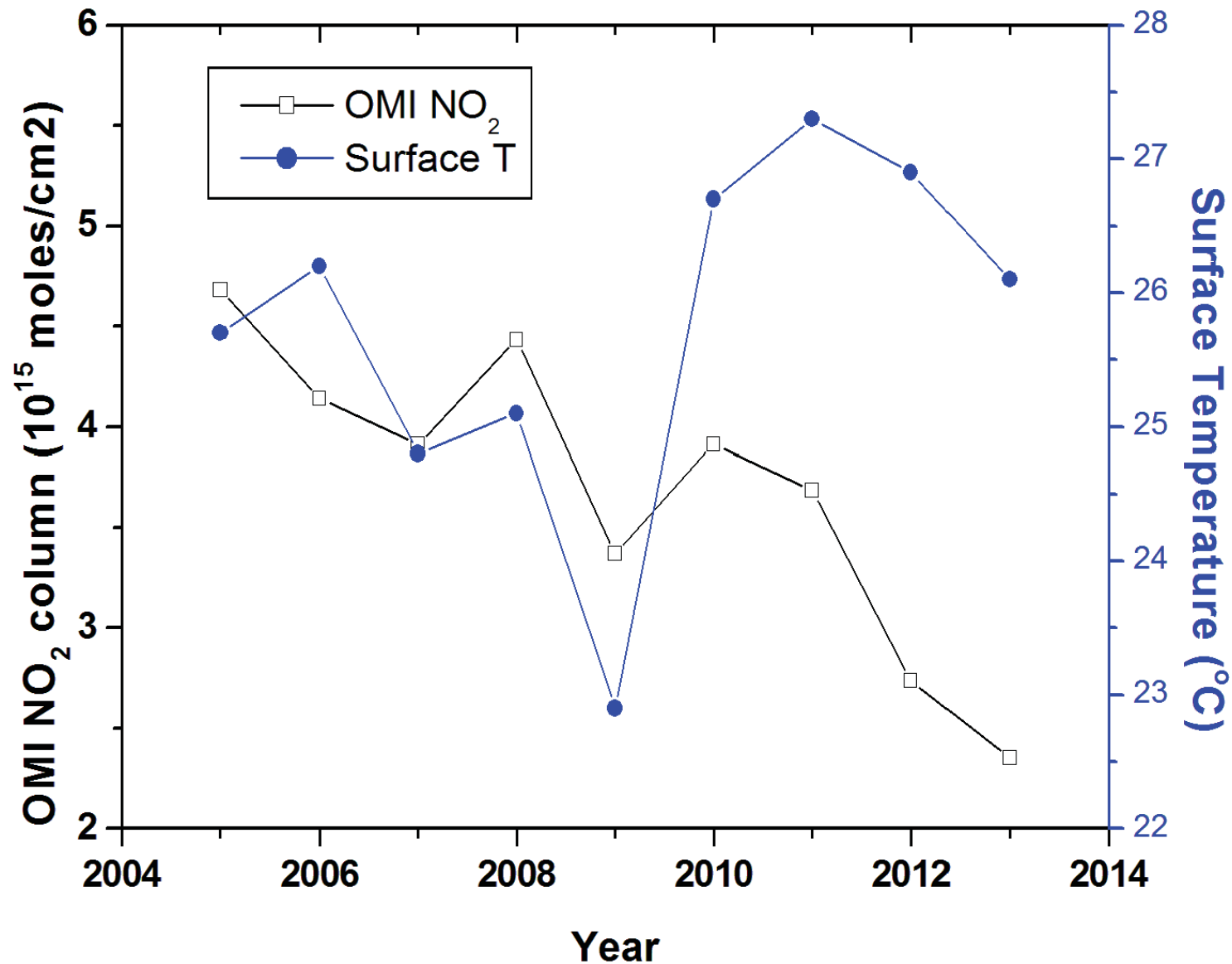


OMI HCHO column vs. Surface Temperature → Stron



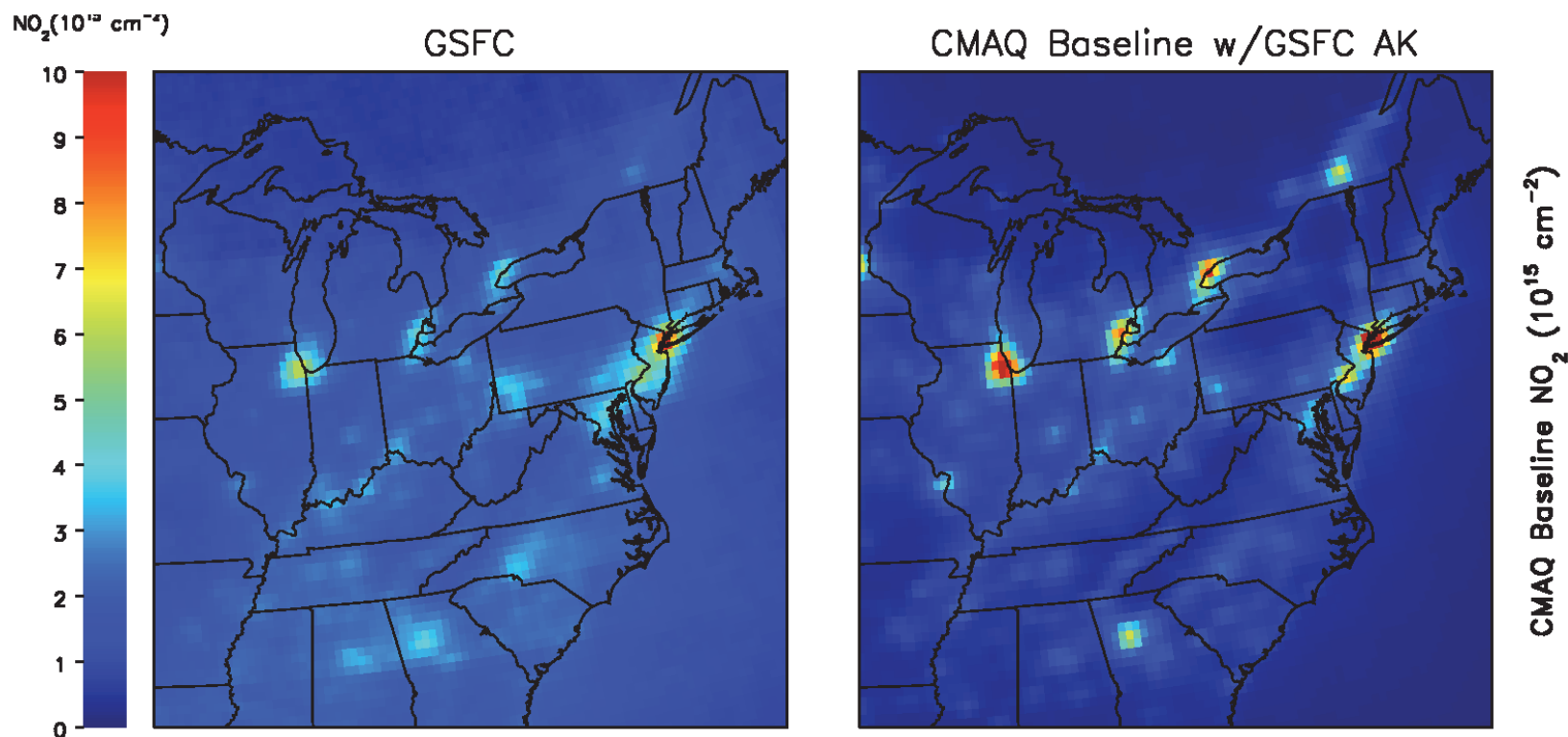
OMI HCHO column vs. Surface Temperature without data from dry year of 2013 → HCHO depends on Temperature!





Time series of July OMI NO<sub>2</sub> column vs. Surface Temperature  
→ Before the local HAA (2010), NO<sub>2</sub> & T are correlated.

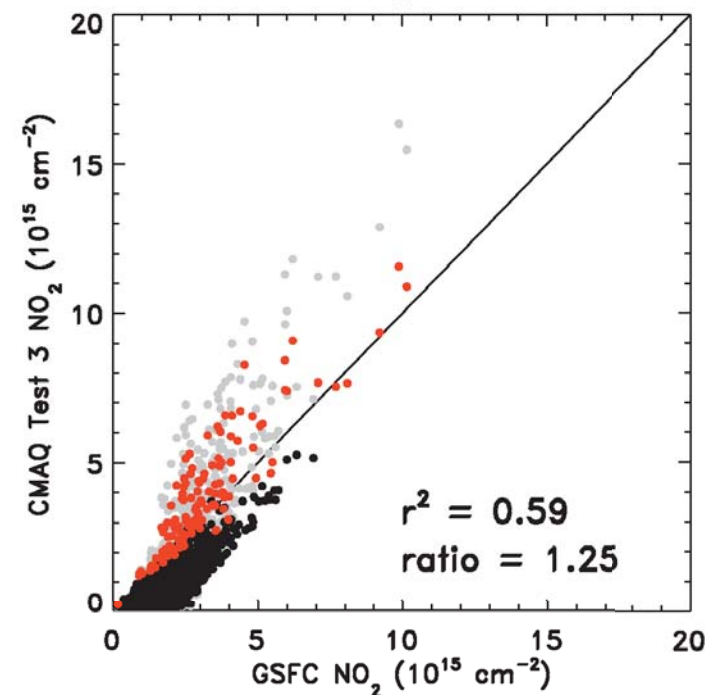
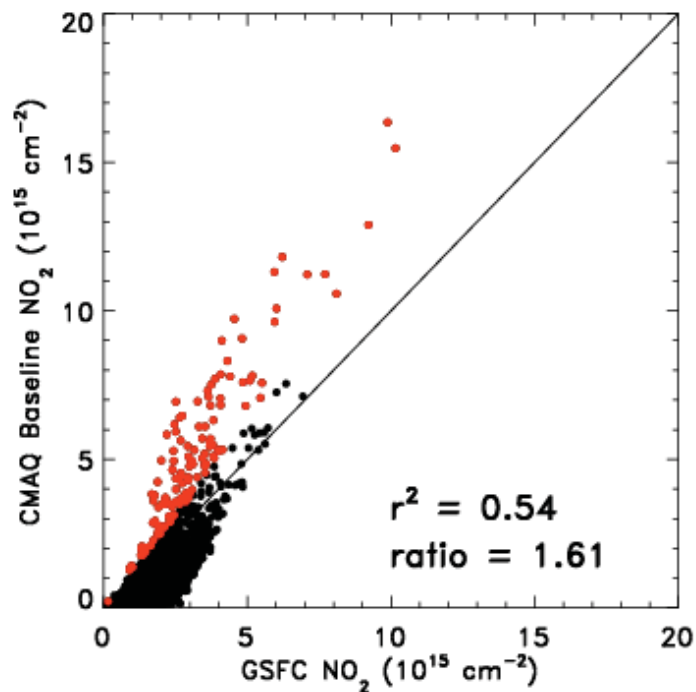
# Canty et al., submitted.



CMAQ modeled NO<sub>2</sub> high in cities low in countryside.  
Inspired by Castellanos et al., 2011.

# Ready results

If CB05 is modified to shorten the lifetime of alkyl nitrates and reduce mobile source NO<sub>x</sub> emissions then CMAQ and OMI agree better.



2004-2009 minus 2010-2012

# Change in SO<sub>2</sub> column from OMI Using Fioletov's sub-pixel resolution product.

